APPENDIX IV

1. Information Provided by GE on April 30, 2008. (43+cover sheet)

Appendix IV

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April 30, 2008

National Transportation Safety Board
Washington DC 20594

Re: NTSB Accident Investigation #DCA-08-MP-001 (Carmichael, MS)
Material provided by GE PII to assist in the investigation.

Ref Doc 1 – Location confirmation.

GE received an XL listing (shown below) from "Dixie" pipelines, which correlated the position of the failure GW, by looking at the Delta joint lengths it is apparent that the joints tie into each other in this listing. GE are therefore satisfied that the GE GW 5808
Corresponds with the Magpie MFL Weld ID# of 58340 as highlighted in pink below.

Magpie MFL Pipelist (selected columns)				GE-PII USCD DHD 105-205 Pipebook data				
ID#	Feature	Wheel Count (ft)	Joint Length (ft)	PipeNo.	Length [ft]	LW [deg]	Comment	Joint Length Delta
57770	WELD	308,078.50	12.15	5753.00	12.07		ERW/FW	-0.08
57780	WELD	308,090.65	1.67	5754.00	1.77		T-Piece	0.10
57790	WELD	308,092.32	0.99	5755.00	6.10		Valve	5.11
57800	WELD	308,093.31	3.87				**MP425.48**	-3.87
57810	WELD	308,097.18	0.99					-0.99
57820	WELD	308,098.17	1.66	5756.00	1.71		T-Piece	0.05
57830	WELD	308,099.83	12.12	5757.00	12.17		ERW/FW	0.05
57840	WELD	308,111.95	2.02	5758.00	1.95		ERW/FW	-0.08
57850	WELD	308,113.98	2.03	5759.00	2.09	73	ERW/FW	0.06
57860	WELD	308,116.01	34.98	5760.00	34.78	355	ERW/FW - T-Piece in Sleeve - Sleeve	-0.20
57870	WELD	308,150.99	58.81	5761.00	58.44	85	ERW/FW - T-Piece in Sleeve	-0.36
57880	WELD	308,209.80	49.18	5762.00	48.83	154	ERW/FW	-0.34
57890	WELD	308,258.97	50.66	5763.00	50.39	260	ERW/FW	-0.26
57900	WELD	308,309.63	57.91	5764.00	57.64	46	ERW/FW	-0.28
57910	WELD	308,367.54	39.83	5765.00	39.62	37	ERW/FW	-0.21
57920	WELD	308,407.37	58.44	5766.00	58.06	163	ERW/FW	-0.38
57930	WELD	308,465.82	55.54	5767.00	55.06	226	ERW/FW	-0.48
57940	WELD	308,521.35	58.81	5768.00	58.52	160	ERW/FW	-0.29
57950	WELD	308,580.16	57.56	5769.00	57.31	8	ERW/FW	-0.25

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F [illegible]

57960	WELD	308,637.72	58.16	5770.00	57.84	37	ERW/FW	-0.32
57970	WELD	308,695.88	59.44	5771.00	59.03	217	ERW/FW	-0.41
57980	WELD	308,755.31	57.02	5772.00	56.65	[illegible]	ERW/FW	-0.37
57990	WELD	308,812.33	58.37	5773.00	57.94	[illegible]	ERW/FW	-0.43
58000	WELD	308,870.71	59.37	5774.00	58.93	279	ERW/FW	-0.44
58010	WELD	308,930.07	58.97	5775.00	58.59	358	ERW/FW	-0.39
58020	WELD	308,989.05	58.76	5776.00	58.47	[illegible]	ERW/FW	-0.29
58030	WELD	309,047.81	57.88	5777.00	57.40	63	ERW/FW	-0.48
58040	WELD	309,105.69	59.15	5778.00	58.67	75	ERW/FW	-0.48
58050	WELD	309,164.84	59.42	5779.00	58.99	4	ERW/FW	-0.42
58060	WELD	309,224.26	58.96	5780.00	58.55	335	ERW/FW	-0.41
58070	WELD	309,283.22	56.95	5781.00	56.57	296	ERW/FW	-0.38
58080	WELD	309,340.17	59.27	5782.00	58.89	36	ERW/FW	-0.38
58090	WELD	309,399.44	57.99	5783.00	57.62	278	ERW/FW	-0.37
58100	WELD	309,457.43	57.71	5784.00	57.31	267	ERW/FW	-0.39
58110	WELD	309,515.14	57.24	5785.00	56.84	351	ERW/FW	-0.40
58120	WELD	309,572.37	59.72	5786.00	59.33	246	ERW/FW	-0.39
58130	WELD	309,632.09	41.15	5787.00	40.84	99	ERW/FW	-0.30
58140	WELD	309,673.24	59.35	5788.00	58.89	191	ERW/FW	-0.45
58150	WELD	309,732.58	57.88	5789.00	57.54	107	ERW/FW	-0.35
58160	WELD	309,790.47	59.11	5790.00	58.74		ERW/FW	-0.37
58170	WELD	309,849.58	58.86	5791.00	58.54	155	ERW/FW	-0.32
58180	WELD	309,908.44	59.06	5792.00	58.91	330	ERW/FW	-0.15
58190	WELD	309,967.50	58.61	5793.00	58.28	65	ERW/FW	-0.33
58200	WELD	310,026.11	58.33	5794.00	57.98	196	ERW/FW	-0.35
58210	WELD	310,084.43	42.40	5795.00	42.20	6	ERW/FW	-0.20
58220	WELD	310,126.83	49.10	5796.00	48.82	255	ERW/FW	-0.28
58230	WELD	310,175.93	36.80	5797.00	36.54	323	ERW/FW	-0.26
58240	WELD	310,212.73	45.38	5798.00	45.17		ERW/FW	-0.21
58250	WELD	310,258.10	41.57	5799.00	41.32	148	ERW/FW	-0.25
58260	WELD	310,299.67	58.68	5800.00	58.37	29	ERW/FW	-0.31
58270	WELD	310,358.35	58.33	5801.00	58.03	43	ERW/FW	-0.30
58280	WELD	310,416.68	59.07	5802.00	58.96	14	ERW/FW	-0.11
58290	WELD	310,475.75	57.49	5803.00	57.35	163	ERW/FW	-0.14
58300	WELD	310,533.24	57.92	5804.00	57.84	62	ERW/FW	-0.08
58310	WELD	310,591.16	59.01	5805.00	58.94	278	ERW/FW	-0.07
58320	WELD	310,650.18	58.19	5806.00	58.13	110	ERW/FW	-0.06
58330	WELD	310,708.36	58.60	5807.00	58.55		ERW/FW	-0.05
[redacted]								
58350	WELD	310,819.09	57.74	5809.00	57.67	137	ERW/FW	-0.07
58360	WELD	310,876.83	52.42	5810.00	52.26	95	ERW/FW	-0.16
58370	WELD	310,929.25	47.92	5811.00	47.87	117	ERW/FW	-0.05
58380	WELD	310,977.17	59.08	5812.00	58.94	23	ERW/FW	-0.14
58390	WELD	311,036.25	52.42	5813.00	52.41	207	ERW/FW	0.00

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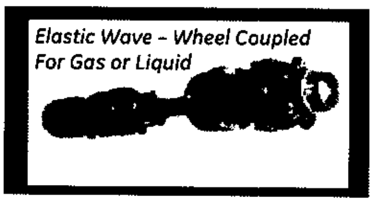
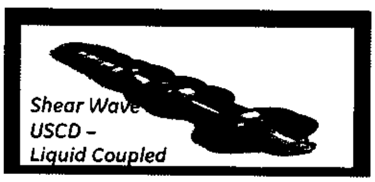
Ref Doc 2 – Crack tools available and selection .

Choosing the right crack tool





Crack type	Liquid	Gas	Capabilities
Pre 1970 ERW Seam Weld Faults	USCD, EW &TransScan	Emat, EW & TransScan	Detection
Surface Breaking Laminations	USCD, EW &TransScan	Emat, EW & TransScan	Detection
	USCD, EW & Transcan	Emat, EW & TransScan	Detection
	USCD	Emat	Detection
	USCD	Emat	Detection
	USCD & EW	Emat & EW	Detection
	USCD & EW	Emat & EW	Detection
	Transcan & USCD	Emat, EW & TransScan	Detection

imagination at work

NB** Some success GL
< 80% GE / April 30 2008

Tools and technology listed above – TFI or Transverse field MFL is a magnetic system which requires a min air gap or crack width of at least 0.004" to leak magnetic flux to allow the detection of a crack like defect. – Elastic Wave – Is a long wave time of flight Ultrasonic tool that fires sound around the circumference of the pipe, bouncing sound from internal to external pipe walls. - USCD is a short wave high-density 45 deg shear wave Ultrasonic tool. – The Emat is a Electro magnetic acoustic transducer tool that excites the pipe wall in such a way that it acts like an Ultrasonic device and sends sound around the pipe in a circumferential direction. The Phased Arrays USCD tool uses a matrix of ultrasonic sound arrays (in various programmed modes) to travel into the pipe in various different directions – this is similar technology used in medical body scanner imagery. Emats and Phased Arrays are the latest developments in crack tool technology.

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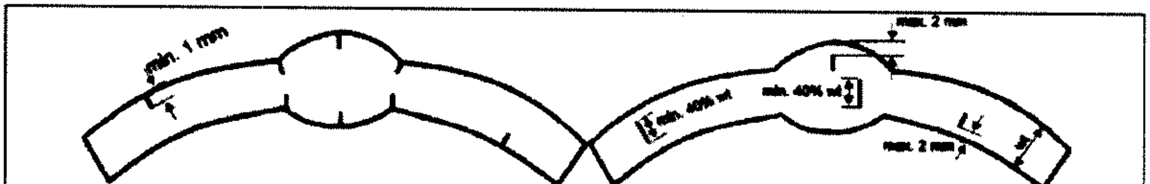
Ref Doc 3 – 2005 USCD tool spec for Dixie Contract.

[redacted]

	Isolated radial cracks with longitudinal Orientation		Clusters (like SCC)	Longitudinal notches and Gouging	Midwall cracks
*: for ILI tools with diameter up to 14" "25mm" is valid	In the plate material, minimum length 30mm*	In the longitudinal Weld area, minimum length 30mm*	Minimum length 30mm*	Minimum length 30mm*	Minimum length 30mm*
Minimum Depth extension At POD = 85% At POD = 95%	1 mm 40% of wt.	1 mm 40% of wt.	1 mm 40% of wt.	1 mm 40% of wt.	2mm (max. 2mm from surface), or 40% of wt. 60% of wt
Depth. grouping In 4 classes at 85% confidence	0 – 12.5% 12.5% - 25% 25 – 40% above 40%	0 – 12.5% 12.5% - 25% 25 – 40% above 40%	0 – 12.5% 12.5% - 25% 25 – 40% above 40%	n/a	n/a
Length sizing Accuracy at 85% Confidence	± 5mm or 1% of length at 1 m/sec	± 5mm or 1% of length at 1 m/sec	± 5mm or 1% of length at 1 m/sec	± 5mm or 1% of length at 1 m/sec	± 5mm or 1% of length at 1 m/sec
Deviation from Longitudinal Orientation	± 10°	± 10°	± 10°	± 10°	± 10°
Internal/external discrimination	Yes	Yes	Yes	Yes	n/a

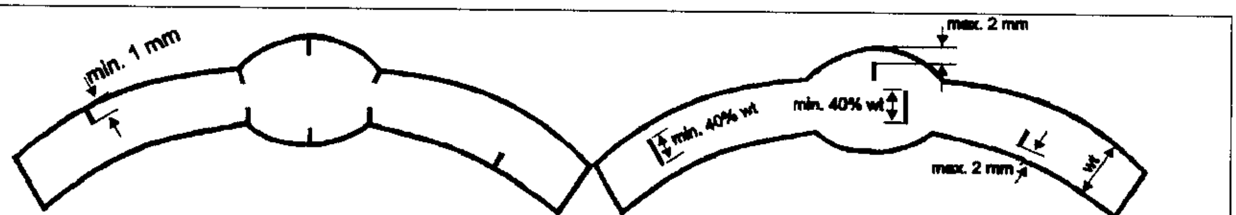


Type of Crack-like Features	The ILI tool will detect all types of radial, longitudinal cracks which terminate in the internal or external wall surface, including the weld bead, as indicated in the sketch above left Typical crack types are single, isolated cracks like toe cracks, fatigue cracks or surface breaking laminations, crack fields, like SCC colonies, or crack-like defects in the weld bead like lack of fusion, undercuts and welding defects.
Midwall Cracks	Will be found when their depth extension is either 40% of wall thickness or, in case the crack has less extension, when the distance between the crack tip and either surface is less than 2mm, as indicated in the sketch above right.
Clusters (like SCC)	Clusters of cracks are detected when the cluster is longer than 30 mm. Individual cracks of at least 1 mm depth within a cluster are allowed to be significantly shorter than 30 mm, provided a couple of neighboured cracks form a chain of at least 30 mm length and the distances between any neighboured, individual cracks are shorter than 5 mm.
Tool Speed	The defect detection capabilities refer to a maximum tool speed of 1 m/s. If the speed increases beyond 1 m/s the minimum detectable crack length increases linearly with speed, i.e. increases from 30 mm to 60 mm at 2m/s.
Wall thickness Measurement	The ILI tool features a number of perpendicular sensors to measure wall thickness. They provide information on the actual wall thickness of the pipe joint. But they are not designed to determine corrosion. Accuracy of the wt measurement: +0.5mm
Location accuracy	Reference girth weld: ± 1% of distance traveled from marker point Defect: ± 0.2m from reference girth weld Circumferential orientation: ± 10°
Other features	The following features are detected by the UltraScan CD, with 90% POI: - Welds (longitudinal, spiral, girth welds) - Fittings with minimum diameter 50 mm - Dents (only dents situated in the path of one of the perpendicular sensors, min. height: 3mm; local "steep" dents)

Note: POD = Probability of detection; POI = Probability of identification

UltraScan CD General Inspection on Longitudinal Cracks In 5mm to 22mm Wall Thickness Pipeline

	Isolated radial cracks with longitudinal Orientation		Clusters (like SCC)	Longitudinal notches and Gouging	Midwall cracks
*: for ILI tools with diameter up to 14" "25mm" is valid	**In the plate material, minimum length 30mm***	**In the longitudinal Weld area, minimum length 30mm***	**Minimum length 30mm***	**Minimum length 30mm***	**Minimum length 30mm***
Minimum Depth extension At POD = 85%	1 mm	1 mm	1 mm	1 mm	2mm (max. 2mm from surface), or 40% of wt.
At POD = 95%	40% of wt.	40% of wt.	40% of wt.	40% of wt.	60% of wt.
Depth, grouping In 4 classes at 85% confidence	0 – 12.5% 12.5% - 25% 25 – 40% above 40%	0 – 12.5% 12.5% - 25% 25 – 40% above 40%	0 – 12.5% 12.5% - 25% 25 – 40% above 40%	n/a	n/a
Length sizing Accuracy at 85% Confidence	± 5mm or 1% of length at 1 m/sec	± 5mm or 1% of length at 1 m/sec	± 5mm or 1% of length at 1 m/sec	± 5mm or 1% of length at 1 m/sec	± 5mm or 1% of length at 1 m/sec
Deviation from Longitudinal Orientation	± 10°	± 10°	± 10°	± 10°	± 10°
Internal/external discrimination	Yes	Yes	Yes	Yes	n/a



Type of Crack-like Features	The ILI tool will detect all types of **radial, longitudinal cracks** which terminate in the internal or external wall surface, including the weld bead, as indicated in the sketch above left. Typical crack types are single, isolated cracks like toe cracks, fatigue cracks or surface breaking laminations, crack fields, like SCC colonies, or crack-like defects in the weld bead like lack of fusion, undercuts and welding defects.
Midwall Cracks	Will be found when their depth extension is either 40% of wall thickness or, in case the crack has less extension, when the distance between the crack tip and either surface is less than 2mm, as indicated in the sketch above right.
Clusters (like SCC)	Clusters of cracks are detected when the cluster is longer than 30 mm. Individual cracks of at least 1 mm depth within a cluster are allowed to be significantly shorter than 30 mm, provided a couple of neighboured cracks form a chain of at least 30 mm length and the distances between any neighboured, individual cracks are shorter than 5 mm.
Tool Speed	The defect detection capabilities refer to a maximum tool speed of 1 m/s. If the speed increases beyond 1 m/s the minimum detectable crack length increases linearly with speed, i.e. increases from 30 mm to 60 mm at 2m/s.
Wall thickness Measurement	The ILI tool features a number of perpendicular sensors to measure wall thickness. They provide information on the actual wall thickness of the pipe joint. But they are not designed to determine corrosion. Accuracy of the wt measurement: ±0.5mm
Location accuracy	Reference girth weld: ± 1% of distance traveled from marker point Defect: ± 0.2m from reference girth weld Circumferential orientation: ± 10°
Other features	The following features are detected by the UltraScan CD, with 90% POI: - Welds (longitudinal, spiral, girth welds) - Fittings with minimum diameter 50 mm - Dents (only dents situated in the path of one of the perpendicular sensors, min. height: 3mm; local "steep" dents)

Note: POD = Probability of detection; POI = Probability of identification

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Doc 3 Propane

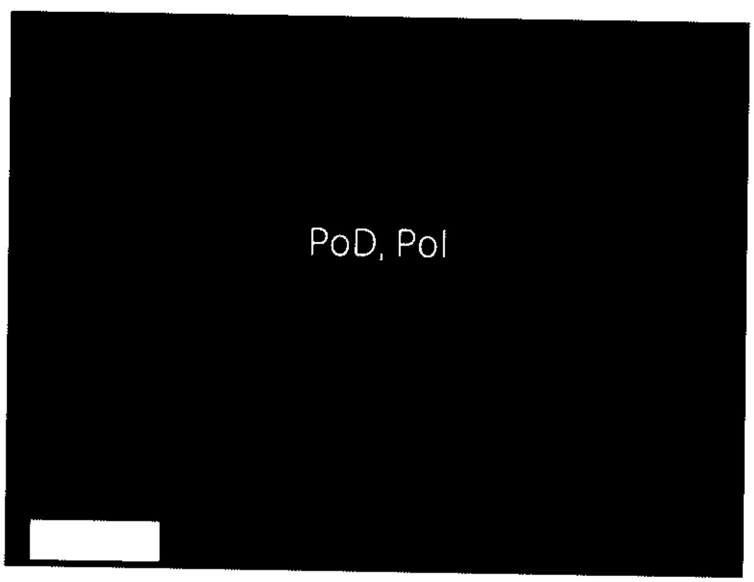
Propane as a coupling for USCD tools.

There is no change in the reporting specification in Propane compared to other Hydro Carbon liquids. The tool is set up with a different sensor angle and signal amplification to accommodate the different attenuation and sound velocity in Propane vs. other hydro-carbon liquids. All Hydro-carbons have different attenuation and sound velocity characteristics and these adjustments (or set ups) are normal.

For every potential ultrasonic inspection (wall measurement as well as USCD) a sample of the pipeline product is analyzed by GE to determine its attenuation and sound velocity characteristics.

In the case of Propane or any liquefied gases, GE requires a full operational profile from the pipeline operator, to make sure these parameters can be maintained (pressure, temperature and flow rate (Volume)) and therefore the liquids properties (attenuation and sound velocity characteristics) do not significantly alter for the duration of the inspection.

Ref doc 4 – POD and POI – Explanation



API 1163
What must ILI vendors supply?

- Can we detect it? – PoD
- Can we classify it correctly? – PoI
- Can we size it accurately? – Sizing Performance
  > Is the other information accurate?
- Can you prove it? – Client Feedback – Dig Verification

Probability of Detection - PoD

API 1163 defines PoD as:

"the probability of a feature being detected by an in-line inspection tool"

What does ***detected*** really mean?

In practice, a defect is detected if:

The inspection tool records a resolvable signal (wrt to the signal noise level) at the defect location

One could go further and say that:

A defect is only detected if that signal has been boxed (or recorded in some way) by either an automatic algorithm or by the analyst

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Probability of Detection - PoD

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A defect is only detected if that signal has been boxed (or recorded in some way) by either an automatic algorithm or by the analyst

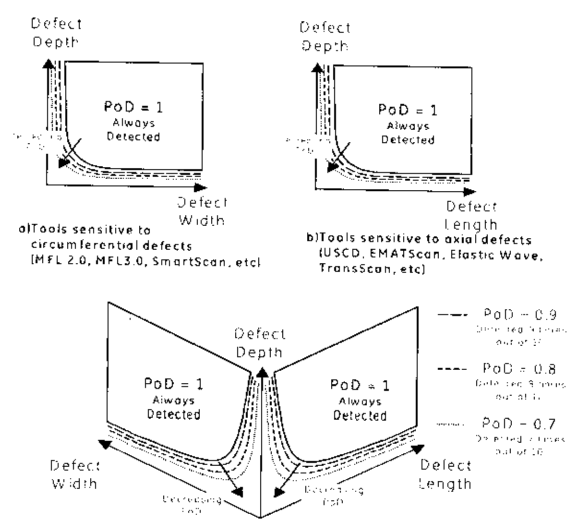
Probability of Detection - PoD

The signal amplitude, and consequently the PoD, is dependent on defect size

The PoD of an inspection system can only be determined from a set of defects whose dimensions have been measured and are known

The PoD is usually derived from pull throughs in spools containing a range of known defects of different sizes

It is expected that the PoD performance achieved by the tool in a pull through will be replicated during each inspection run



c)Tools sensitive to defect volume (Triax, USWM, USDUO, etc)

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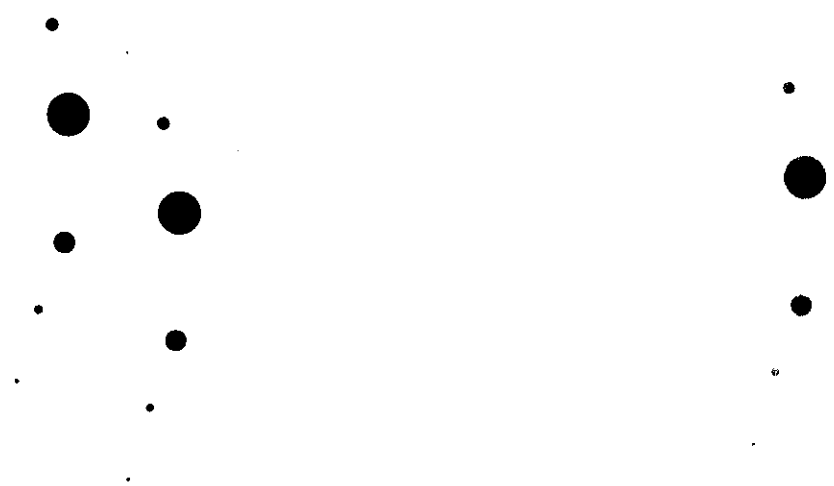
Probability of Detection – PoD

6 dots – 5 colours



The PoD of large dots is 1. The PoD of the smallest dots is <1

PoD depends on size of and shape of defect

Probability of Detection – PoD

How should we calculate PoD?

Example:

- Pull Through Data recorded from
  - > 5 identical defects
  - > Over 10 pull through runs
  - > Signal detected = 48 times - ***TP***
  - > Signal not detected = 2 times - ***FN***

	Defect Detected	
	Yes	No
Known and measured defect of a specific type and size		

$$PoD_{\text{specific defect type and size}} = \frac{TPs}{(TPs + FNs)}$$

$$= \frac{48}{48+2} = 0.96$$

If there is only one defect of each size in the pull through then from a single run the PoD for ecch defect can only be calculated to be either 1 or 0

So a number of repeat runs and/or duplicate defects are needed to enable a more meaningful PoD value to be calculated

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Probability of Identification - PoI

API 1163 defines PoI as:

"the probability that the type of anomaly or other feature, once detected, will be correctly identified (e.g. as metal loss, dent, etc.)"

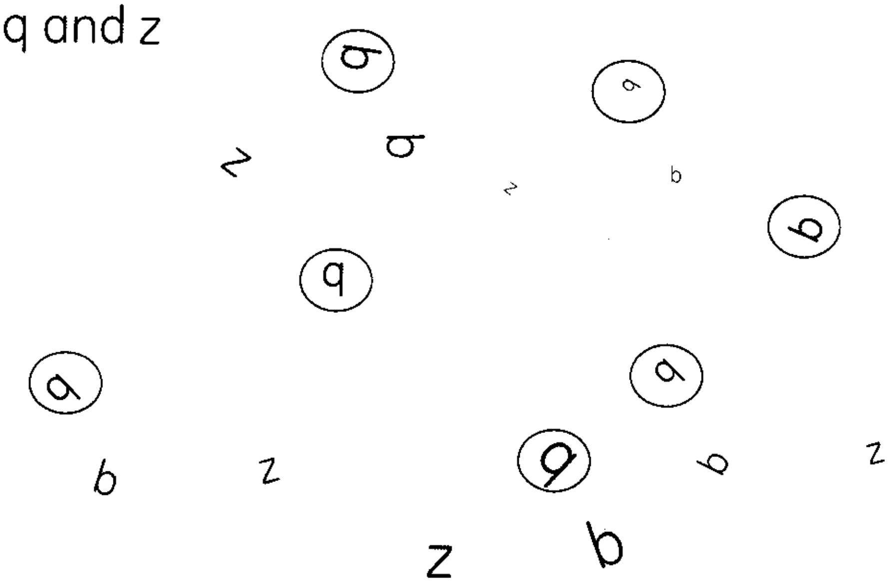
The PoI of an inspection system can only be determined from a set of defects where we have **both**

the analyst's classification

AND

the in-the-ditch classification made by a competent NDE/NDT operator

Probability of Identification – PoI
b, q and z



Our ability to classify z prevents p & q being misclassified as z
PoI on a particular pipeline depends on mix of defect types

Probability of Identification – PoI

How should we calculate PoI?

From the analysis results and the excavation data:

- Defects reported as Defect Type X (such as crack) and assessed in-the-ditch as of Defect Type X are ***true positives***
- Defects reported as Defect Type X but assessed in-the-ditch as **not** of Defect Type X are ***false positives - (False Digs)***
- Defects reported as **not** Defect Type X but assessed in-the-ditch as of Defect Type X are ***false negatives - (Missed Threats)***
- Defects reported as **not** Defect Type X and assessed in-the-ditch as **not** of Defect Type X are ***true negatives***

		Excavated: Crack	Excavated: Not a Crack
Reported	Crack	[redacted]	FP
	Not a Crack	[redacted]	TN

$$PoI_{\text{specific defect type}} = \frac{\text{No. of correct identifications}}{\text{No. of opportunities to classify a defect}}$$

$$= \frac{TPs + TNs}{(TPs + FNs + FPs + TNs)}$$

Probability of Identification – PoI

How should we calculate PoI?

Example:

- 50 features were reported and excavated
- 15 of these were reported as Cracks
  - > 10 were found to be cracks – ***TP for Cracks***
  - > 5 were classified in-the-ditch as metal loss - ***FP***
- 35 of these were reported as Notch-like
  - > 33 were classified in-the-ditch as notch-like - ***TN***
  - > 2 were found to be cracks – ***FN***

		Excavated: Crack	Excavated: Not a Crack
Reported	Crack	[redacted]	FP
	Not a Crack	[redacted]	TN

$$PoI_{\text{Cracks}} = \frac{TPs + TNs}{(TPs + FNs + FPs + TNs)}$$

$$= \frac{10 + 33}{10 + 2 + 5 + 33} = 43/50 = 0.86$$

$$PoI_{\text{Notch-like}} = \frac{33 + 15}{33 + 0 + 2 + 15} = \frac{48}{50} = 0.96$$

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Ref Doc 5 – USCD classification descriptions

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UltraScan CD Classification

Classification PII	API1163 /POF	Description
Crack Field	SCC	Colony of planar, two-dimensional features with displacement of the fracture surfaces (SCC).
Crack-Like	Crack	A planar, two-dimensional feature with displacement of the fracture surfaces.
Notch-Like	Gouge	Mechanically induced metal-loss, which causes localized elongated grooves or cavities.
Weld Anomaly	Weld Anomaly	Anomaly in the body or the heat affected zone of a weld.
Metal Loss	Corrosion	An electrochemical reaction of the pipe wall with its environment causing a loss of metal.
Inclusion-Like	Mid wall feature	Any feature which does not run out to either the internal or external surface.
Lamination	Lamination	Imperfection or discontinuity with a layered separation that may extend parallel or angular to the pipe wall surface.
Dent / Deformation	Dent	Distortion of the pipe wall resulting in a change of the internal diameter but not necessarily resulting in localised reduction of wall thickness.
Not Decidable		Features that cannot be assign to one of the classifications above. Describing comment need to be added.

Ref Doc 6 – General information and types of defects detected by USCD

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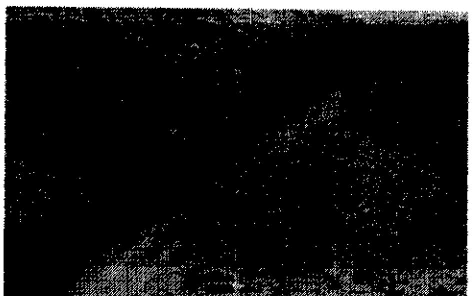
1 General Information on the UltraScan CD

In order to continue safe operation, pipeline operators in many countries have to prove the integrity of their lines. Increasing the operationally safe lifetime of a pipeline might be severely impacted by the presence of various undetected damage mechanisms. Corrosion, for example, in the course of time can cause wall thinning or may even lead to crack generation and growth when combined with tensile stresses (SCC - stress corrosion cracking). Fatigue loading can also lead to crack generation especially in the heat affected zone of the longitudinal weld.



pipeline rupture at longitudinal weld

In order to avoid catastrophic pipeline failures due to such defects, it is necessary to periodically inspect pipelines – in particular older pipelines - by non-destructive inspection techniques. Normally, such inspections are performed 'in-line' using intelligent pigs. While the detection of metal loss (corrosion) with ultrasonic tools or MFL (Magnetic Flux Leakage) tools has been state-of-the-art for some decades, tools for the much more difficult task of crack detection were missing until 1994, when PII Pipeline Solutions introduced an ultrasonic pig for the detection and sizing of axially oriented crack-like anomalies (fatigue cracks, SCC etc.) – the UltraScan CD tool.

In contrast to the ultrasonic corrosion inspection, which uses longitudinal sound waves propagating perpendicularly (90°) into the pipe wall, the crack detection tool is based on a transverse sound waves inspection. This is accomplished by angling the incident of ultrasonic pulses through the liquid coupling medium (e.g. crude oil), resulting in a 45° refracted transverse sound path being generated in the pipe wall.

To date, more than 9500 Miles of oil and gas pipeline have been inspected worldwide using the PII Pipeline Solutions' proven ultrasonic technology. The experience gained so far has resulted in the UltraScan CD tool being officially accepted by the German TÜV authority [1]. In combination with a defect assessment program the tool can replace hydrostatic testing for crack related failures. Regulators in further countries, e.g. the National Energy Board (NEB) in Canada or the Department of Transportation (DOT) in USA are aware of its capabilities and appreciate its performance.

[1] Verfahrensgutachten *Ultraschall-Rißprüfmolch "UltraScan CD" der Fa. Pipetronix GmbH*, TÜV Rheinland, Köln. Aug. 1995.
(Report *Ultrasonic Crack Detection Pig "UltraScan CD" of Pipetronix GmbH*, TÜV Rheinland, Köln. Aug. 1995.)

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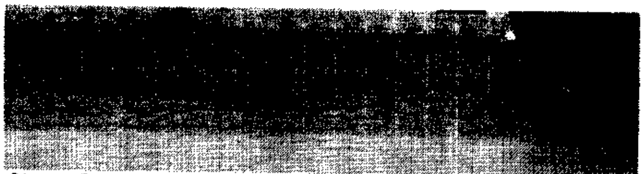
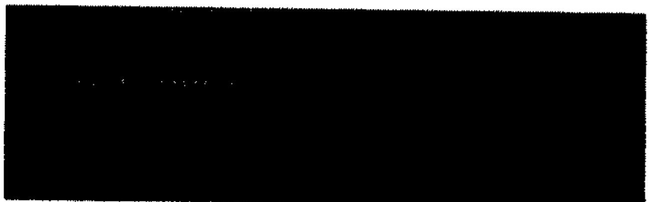
2 Features Detectable With UltraScan CD

Cracks undoubtedly represent the most serious threat to a pipeline's integrity. Different types of longitudinal cracks are found in pipelines, the most prevalent and important ones being

- Fatigue Cracks, caused by permanent cyclic loading
- Stress Corrosion Cracking (SCC), known to develop under simultaneous presence of tensile stress and corrosion attack
- Toe Cracks along seam welds



Stress Corrosion Cracking



Hook Crack

UltraScan CD is designed to identify and size cracks and crack-like defects as short as 1 inch for tools up to 14" and 1.2 inch for tools greater than 14" and as shallow as 40 mil. It has consistently proven its unique capabilities in more than 9500 Miles of analysed data since its market introduction in 1994.

It is the only technology for reliably detecting the shallowest and narrowest cracking of all types, including incipient Stress Corrosion Cracking (SCC). Locations and sizing of defects detected by the tool have been verified in over 300 excavations.

One of the most difficult challenges in pipeline integrity management is the issue of managing stress corrosion cracking (SCC) so that failures can be prevented. SCC can occur in a number of locations, therefore the only reliable way for operators to deal with the issue, other than by hydrostatic re-testing, is by using in-line inspection tools capable of detecting, discriminating and sizing all SCC features in a pipeline.

Based on our experience along with in-field verifications, the UltraScan CD tools prove to have very high Probability of Detection (POD). Cracks in pipelines are among the most severe and potentially dangerous defects in pipelines. In particular, stress corrosion cracking (SCC) has already caused a significant number of service failures in gas pipelines as well as in crude oil pipelines all over the world. Recent incidents throughout North America and the world, including Australia, Russia, Saudi Arabia, and South America, have highlighted the threats to pipelines from SCC. In the United States, SCC failures on hazardous liquid pipelines have been less frequent when compared with SCC occurrences on natural gas pipelines. In Canada, The National Energy Board (NEB) reported that approximately 15 to 20 percent of the failures were attributable to SCC.

A pipeline is especially susceptible to SCC and other cracks if combinations of two or more factors are present:

- There is coating disbondment
- Stresses are present due to manufacturing or corrosion
- High temperatures
- Areas near compression stations
- Less than adequate CP conditions
- Cyclical pressure
- Bacterial activity

The **"Weld Anomaly"** feature type was introduced in compliance with API 1163. It refers to anomalies in the heat-affected zone of a weld which do not meet all criteria for a Crack-Like classification. In the past, these anomalies would have been classified as one of the following feature types along with a clarifying comment:

- Notch-Like, *comment:* possibly weld defect
- Crack-Like, *comment:* possibly weld defect
- Notch-Like, *comment:* probably indication from weld
- Crack-Like, *comment:* probably indication from weld

Anomalies detected by the UltraScan CD tool that meet all the criteria for a Crack-Like classification are still reported as Crack-Like features.

Weld anomalies may be caused by one of the following weld defects:

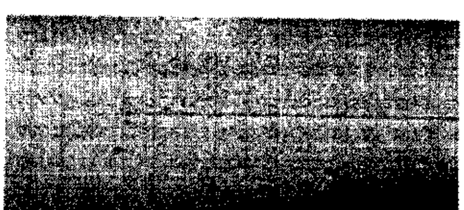
- weld crack
- hook crack
- shrinkage crack
- lack of fusion
- undercut

Weld anomalies may also be caused by welding faults, such as:

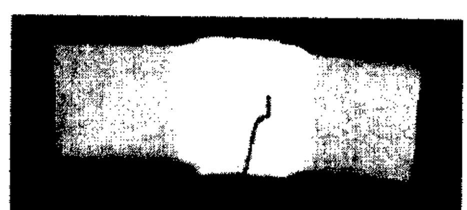
- misalignment (high-low)
- irregular or excessive trim
- inadequate trim

Weld anomalies as described above mainly occurr in ERW or FW pipes, some of them can also be present in SAW pipes.

Pictures of Weld Anomalies:



Weld Crack



Hook Crack

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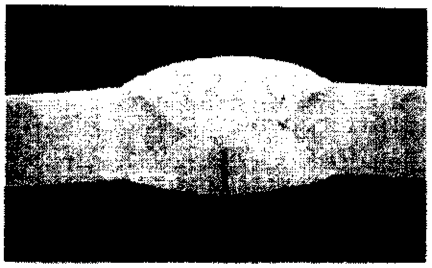
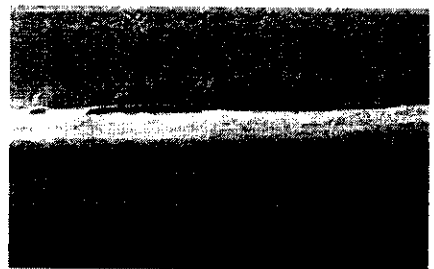
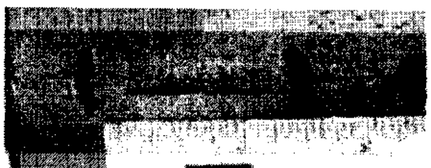


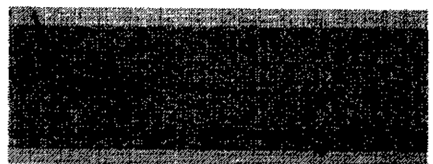
Shrinkage Crack



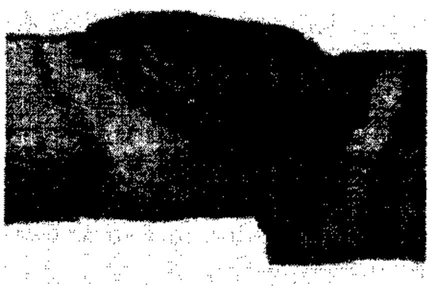
Undercut



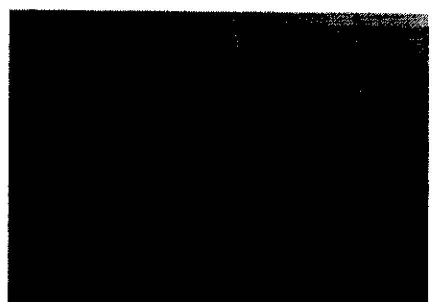
Lack of Fusion



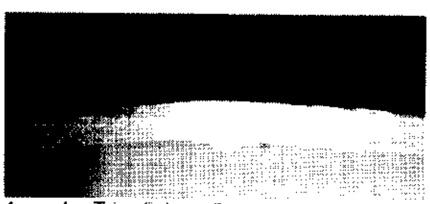
Inadequate Flash Trim



Misalignment (High-Low)



Irregular Trim (external)



Irregular Trim (internal)

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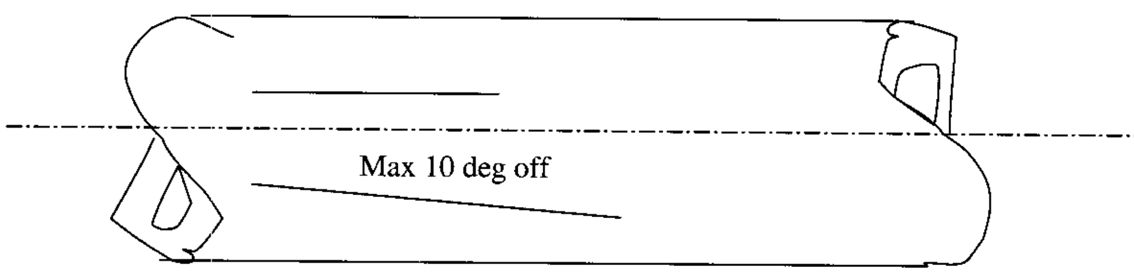
Ref Doc 7 - Questions about the USCD technology and Reporting spec.

1.Can the GE-PII USCD tool detect circumferential defects?
Specifically near and in the girth welds?
GE Answer: No, only axial defects can be detected by the USCD tool and only if they lie within +/- 10 degrees of the pipe axis, as shown below.



2. Please provide a definition for notch like features.
GE Answer: Notch-Like is the classification used for linear indications, showing a straight characteristic in parallel to the axial direction.
Notch-Like indications are generally caused by grooves or gouges brought into the material during pipe manufacturing or pipeline construction (e.g. drawing groove).

The classification Notch-like is also used for linear indications at the seam weld with a clarifying comment:
Notch-Like, comment: possibly weld defect
Notch-Like, comment: probably indication from weld
Notch-Like - possible weld defect may be caused by actual weld defects as:
Weld cracks
Hook cracks
Shrinkage cracks
Lack of fusions
Undercuts

Notch-Like - probably indication from weld may be caused by actual weld defects as:
Misalignment (high-low)
Irregular or excessive trim
Inadequate trim

The classification Notch-Like - possibly weld defect or Notch-Like - probably indication from weld and weld anomaly is mainly used for anomalies in ERW (Electric Resistance Welded) or FW (Flash Welded) pipes i.e. where no filler material is used.
The classification Notch-Like - possibly weld defect or Notch-Like - probably indication from weld, weld anomaly was replaced by the classification weld anomaly in 2007.

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3. What is the tool tolerance for depth and length? Please confirm +/- 10% for depth and +/- 1% for length dimensions if features that meet minimum size criteria.
GE Answer: USCD does not give the tolerances you mention, these are typical MFL tolerances not Crack detection.
USCD:-
- Depth grouping in 4 bands at an 80% certainty with ±16 mil (±0.4mm) tolerance or at 90% certainty with ±20mil (±0.5mm) tolerance.
  0-12.5%WT
  12.5-25%WT
  25-40%WT
  40-100%WT

- Length sizing accuracy at 80% certainty ±0.3inch (±7.5mm) or ±7.5% of length.
- Length sizing accuracy at 90% certainty ±0.4inch (±10mm) or ±10% of length

4.How were the depth ranges and the tool tolerance determined for the GE-PII USCD tool?
GE Answer: Ultrasound is measured in decibels or dbs of reflected sound returning to a transponder. The USCD sensors and transponders are angled to transmit and receive sound at 45 degs around the circumference of the pipe, due to this angular effect, it is necessary to select depth bands that can be clearly delineated and thus the bands were created. The reflectors generated from cracks that are deeper than 40% of the pipe wall will totally saturate the responders and therefore it is impossible to predict the max depth of cracks that are deeper than 40%, hence the final band is everything > 40%.

5. How can the features be reported as less than 12.5% in depth if the minimum depth criteria are 0.04 inches, which is 16% for 0.250 nominal wall thickness pipes?
GE Answer: The USCD tool can detect features below the minimum specified depth. However, not to the confidence levels we have stated in the specification. If we find any features below the min depth specification and have analyzed then, we will include them in the report for completeness, BUT they are not within the Contracted tolerances stated, as they are "officially" below the Contractual specification in the Contract. This is done to try and eliminate confusion during excavations, so that smaller cracks are not misinterpreted for the larger ones and to give confidence in the detection capabilities of the tool.

6.GE identified 33 other signals in pipe 5808. One of these indications was aligned with the long weld. Were the other 32 other signals adjoining the weld?
GE Answer: A total number of 33 reflectors were recorded by the tool in joint 5808. 10 of theses 33 reflectors were in the area adjacent to the long seam weld, this includes the one mentioned in the question above. Only 3 reflectors were of sufficient magnitude to allow full analysis, and only 2 were within our analysis criteria and therefore included in the final report.

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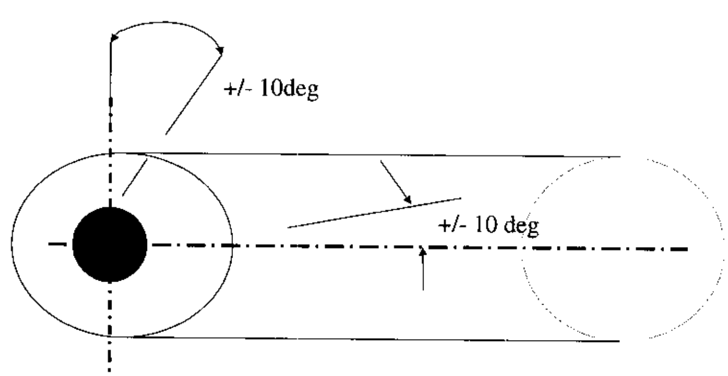
7. Define the term in the report "adjoining the weld" with Specific dimensions referenced to the long seam weld position.
GE Answer: Features within a range of 0.787inch (20mm) on either side of the long seam weld will be given the nomenclature of "adjoining the weld".

8. Does GE-PII have any inline inspection tools that can assess the girth weld for defects like metal loss, porosity, cracking, etc.?
GE Answer: For GW w/ Metal Loss & For Porosity – Circumferential Cracking - No Ultrasonic's tool.

MFL tools have detected and reported defects in the Circumferential or Girth welds in the past. The defect must have sufficient width to cause the magnetic field to leak from the pipe. MFL tools measure the volumetric magnetic flux leaking from

the pipe, which is caused by a lack of material. The issue comes with discrimination; it is very difficult to characterize the signals when associated with the girth weld. Standard practice is to call them all Girth Weld Anomalies with an associated circumferential extent/measurement - but no depth. The only discrimination made is when there is obvious corrosion in the vicinity. The signals then would then be classified as metal loss.

Further clarification of the Planar orientation tolerances of cracks is shown below.



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Ref Doc 9 – The actual reported features in Joint 5808

The features analyzed in the failure joint are indicated below

A total number of 33 reflectors were captured by the tool for this joint of pipe. Only 3 sets of "reflectors" met the criteria for area creation, were analyzed and classified as follows:-

(1) 16-00689, Inclusion-like (Non Reportable)
(2) 16-00737, Notch-like, <12.5%
(2) 16-00728, Geometry, Deformation

(The extracted page from the final Inspection report shown below indicates these features):- In Pipe Number 5808.00
Feature 16-00737 at 51.43ft from the Upstream GW,
Feature 16-00728 at 52.85ft from the Upstream GW
Both these features were close to, or adjacent to, the Down Stream Girth Weld and were characterized as a Notch-like <12.5% x 4.6 inches long, and an associated Geometry Deformation feature, 2.8 inches long. The other analyzed feature 16-00689 was identified as an inclusion in the steel and therefore not reportable.

Start Distance 15.19 ft   End Distance 636233.04 ft

No.	Area No.	Pipe No.	L.W. [°]	Wt. [mil]	DuGW [ft]	DdGW [ft]	Distance [ft]	Deg [°]	Length [in]	Width [in]	Est. Depth [%WT]	Rel. Pos	Rad. Pos.	Type	Comment
DHD205	0016-00636	5800.00	29	235.0	55.59	2.88	308750.40	34	2.00	1	<12.5	aw	External	Notch-Like	poss. weld defect
DHD205	0016-00733	5800.00	29	235.0	57.57	0.49	308752.56	36	1.40	2	<12.5	aw	External	Notch-Like	poss. weld defect - near GW
DHD205	0016-00639	5801.00	43	235.0	0.29	57.73	308753.37	46	3.50	1	25-40	aw	External	Crack-Like	poss. weld defect - near GW
DHD205	0016-00640	5801.00	43	235.0	2.31	55.71	308755.39	46	4.00	1	<12.5	aw	External	Crack-Like	intermittent - poss. weld defect
DHD205	0016-00641	5801.00	43	235.0	10.21	47.82	308763.29	44	1.30	0	<12.5	aw	External	Crack-Like	poss. weld defect
DHD205	0016-00752	5801.00	43	235.0	13.46	44.56	308766.55	44	4.20	1	12.5-25	aw	External	Crack-Like	poss. weld defect
DHD205	0016-00753	5801.00	43	235.0	18.56	39.17	308771.94	46	1.80	1	<12.5	aw	External	Crack-Like	poss. weld defect
DHD205	0016-00642	5801.00	43	235.0	20.30	37.72	308773.38	46	2.80	1	25-40	aw	External	Crack-Like	poss. weld defect
DHD205	0016-00646	5801.00	43	235.0	34.93	23.09	308788.01	46	3.20	1	12.5-25	aw	External	Crack-Like	poss. weld defect
DHD205	0016-00649	5801.00	43	235.0	46.21	12.82	308799.29	44	1.60	1	12.5-25	aw	Not decidable	Crack-Like	poss. weld defect
DHD205	0016-00650	5801.00	43	235.0	47.79	10.25	308800.86	44	1.90	1	12.5-25	aw	External	Crack-Like	poss. weld defect
DHD205	0016-00651	5801.00	43	235.0	49.43	8.60	308802.50	44	4.30	1	12.5-25	aw	External	Crack-Like	poss. weld defect
DHD205	0016-00746	5802.00	14	235.0	35.01	23.95	308846.12	16	1.80	1	<12.5	aw	Not decidable	Crack-Like	poss. weld defect
DHD205	0016-00658	5802.00	14	235.0	56.73	2.23	308867.83	20	2.30	1	12.5-25	aw	External	Crack-Like	poss. weld defect
DHD205	0016-00660	5803.00	163	235.0	30.32	37.23	308892.38	166	4.00	1	12.5-25	aw	External	Notch-Like	poss. weld defect
DHD205	0016-00661	5803.00	163	235.0	38.18	27.17	308900.24	172	2.00	1	<12.5	aw	External	Notch-Like	poss. weld defect
DHD205	0016-00727	5804.00	62	235.0	36.22	21.62	308963.63	64	3.20	1	<12.6	w	External	Notch-Like	poss. weld defect
DHD205	0016-00673	5804.00	62	235.0	40.41	17.43	308967.83	64	1.40	1	12.5-25	w	External	Notch-Like	poss. weld defect
DHD205	0016-00690	5806.00	276	235.0	28.51	30.43	309013.77	279	2.00	0	<12.5	aw	External	Notch-Like	poss. weld defect
DHD205	0016-00691	5806.00	276	235.0	35.21	23.71	309020.48	279	1.60	0	<12.5	w	External	Notch-Like	poss. weld defect
DHD205	0016-00754	5806.00	276	235.0	37.70	21.25	309022.96	278	4.20	1	12.5-25	aw	External	Crack-Like	possibly mill trim traces
DHD205	0016-00682	5806.00	278	235.0	40.03	18.91	309025.29	278	5.60	0	12.5-25	aw	External	Crack-Like	possibly mill trim traces
DHD205	0016-00686	5808.00	110	235.0	26.24	32.69	309089.43	112	11.00	1	<12.5	aw	Not decidable	Notch-Like	poss. weld defect
DHD205	0016-00687	5808.00	110	235.0	44.19	13.94	309088.38	114	1.20	0	<12.6	aw	External	Notch-Like	poss. weld defect
~~DHD205~~	~~0016-00689~~	~~5808.00~~	~~110~~	~~235.0~~	~~46.60~~	~~12.02~~	~~309094.60~~	~~114~~	~~4.20~~	~~0~~	~~<12.5~~	~~aw~~	~~External~~	~~Notch-Like~~	~~poss. weld defect~~
DHD205	0016-00737	5808.00	225	235.0	51.43	0.66	309212.31	17	4.60	1	<12.6	bm	Internal	Notch-Like	near GW - next to deformation
DHD205	0016-00728	5808.00	223	235.0	51.86	0.23	309212.73	14	2.80	2		bm	Not decidable	Geometry	deformation - at GW
DHD205	0016-00692	5809.00	137	235.0	11.60	46.07	309224.57	141	2.70	1	<12.5	aw	External	Notch-Like	poss. weld defect
DHD205	0016-00693	5809.00	137	235.0	52.99	4.69	309265.96	139	1.60	0	<12.6	aw	External	Notch-Like	poss. weld defect
DHD205	0017-00002	5810.00	96	235.0	30.43	21.88	309301.07	98	1.30	1	<12.5	aw	External	Notch-Like	poss. weld defect
DHD205	0017-00004	5810.00	96	235.0	46.51	6.74	309316.14	98	4.00	0	12.5-25	aw	External	Notch-Like	poss. weld defect

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Joint where failure occurred – 2 features in report

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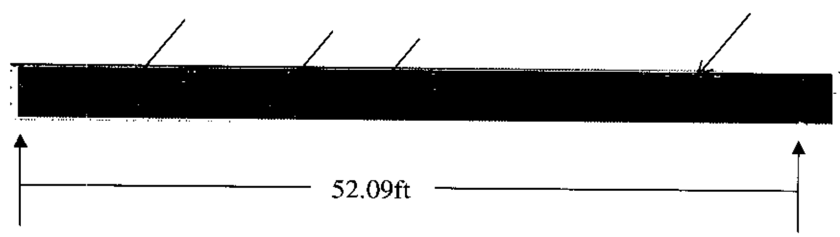
Ref Doc 8 – 33 reflectors in the USCD Data in 5808

Joint 5808.00 viewed to scale

(52.09ft as seen by the USCD Tool)

Ultrasonic "reflectors" (Please Refer to Slide 2 for detail)



True aspect ratio (length vs. Circumferential width) showing the position (Scatter pattern) of reflectors

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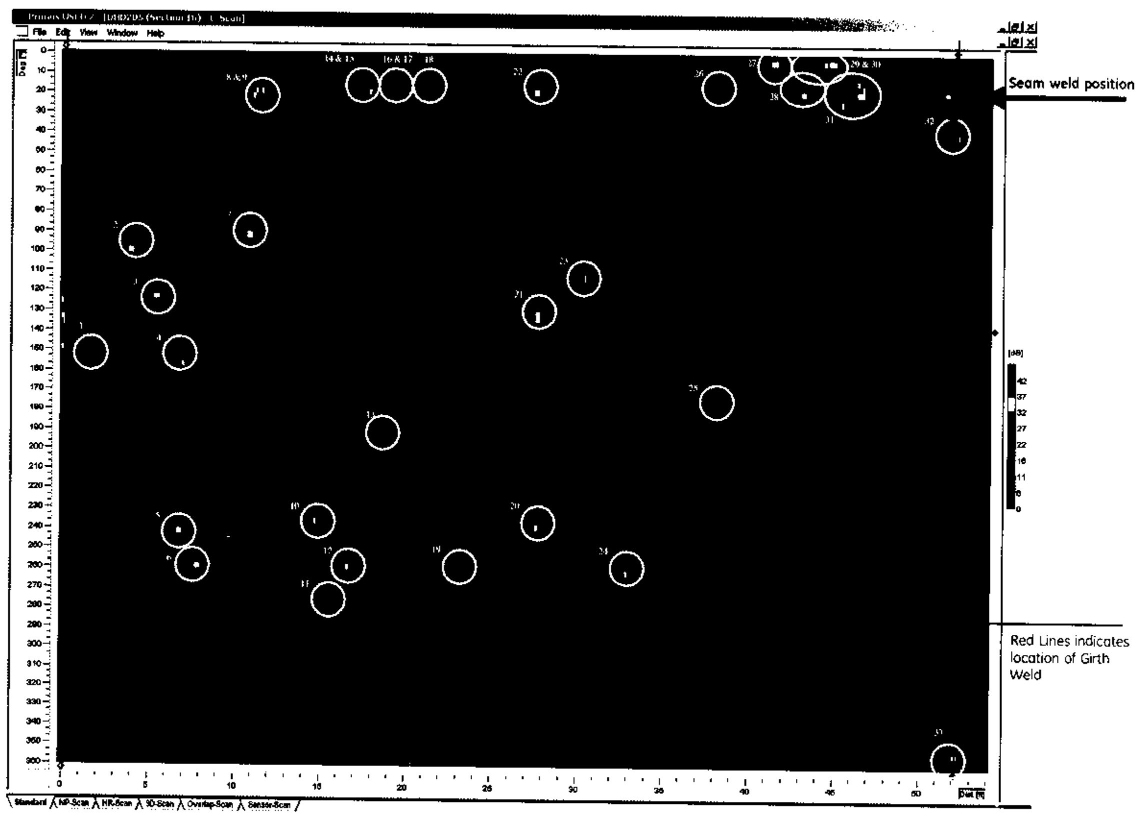

imagination at work

Magnified view to identify individual reflectors

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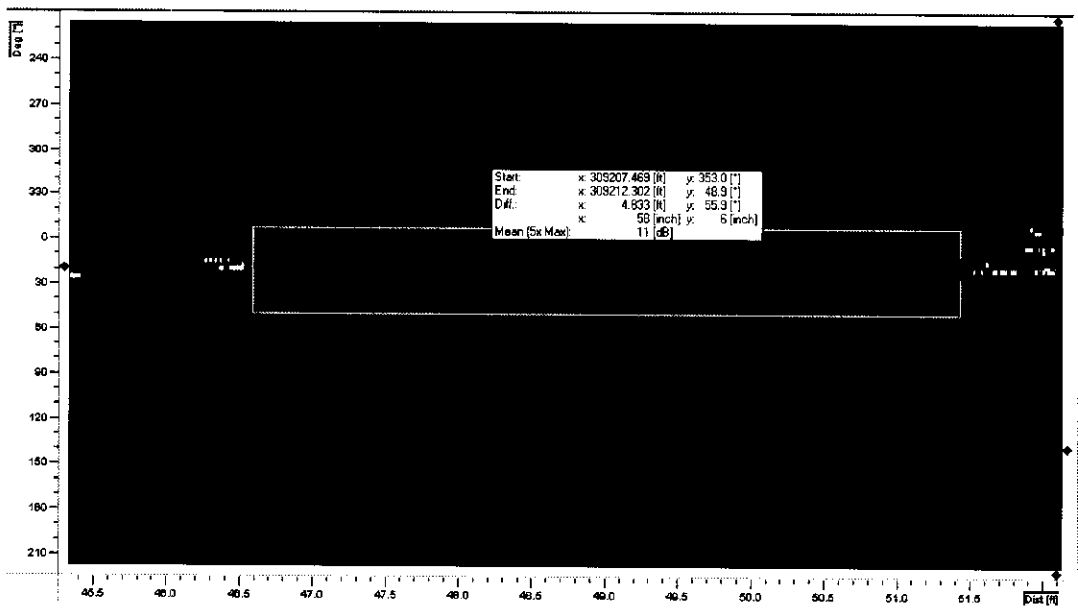
33 "reflectors" in the Ultrasonic data. These reflectors did not meet the requirement for area creation.

3 "reflectors met the criteria for area creation, where analyzed and classified as follows:
(1)16-00689, Inclusion-like (Non Reportable)
(2) 16-00737, Notch-like, <12.5%
(2) 16-00728, Geometry, Deformation



Magnified view of the reported feature adjacent to the DS GW Identified as the **number 2** nearest reflector is 4.83ft.

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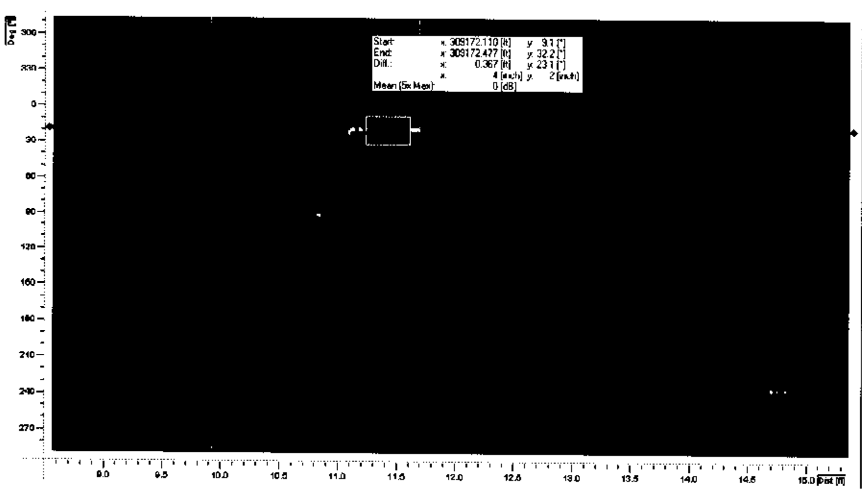
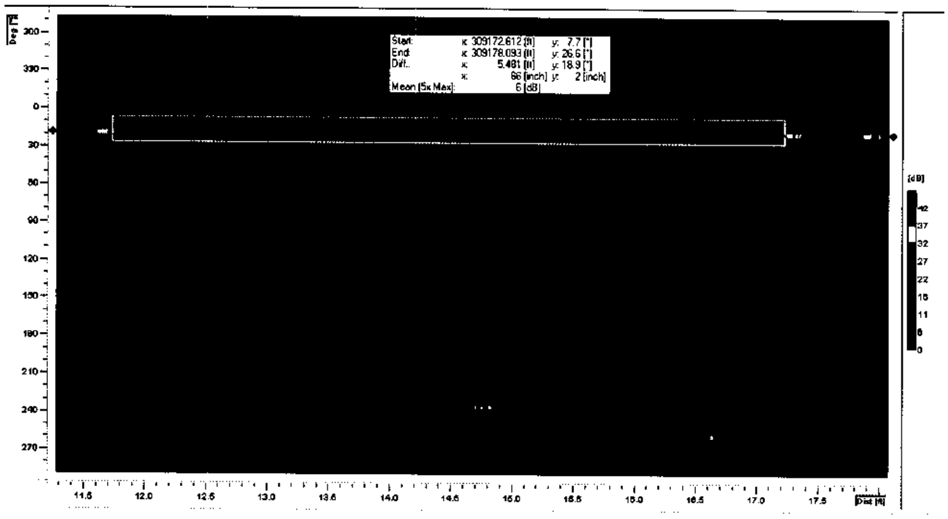
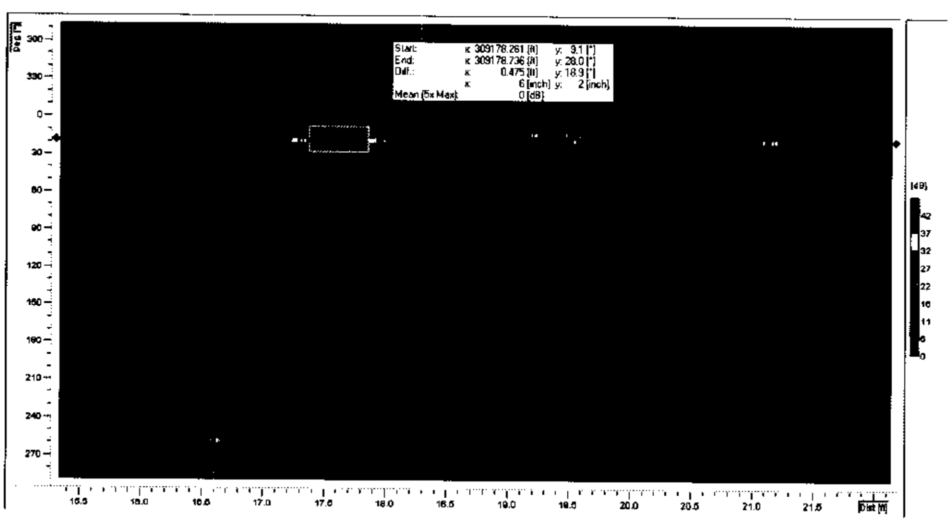
Ref Doc 9 – details of reflectors along the seam weld



Distance between reflector Identified as numbers
8 & 9 is 4 inches



Distance between reflector Identified as numbers
(8 & 9) and (14 & 15) is 66 inches



Distance between reflector Identified as numbers
14 & 15 is 6 inches

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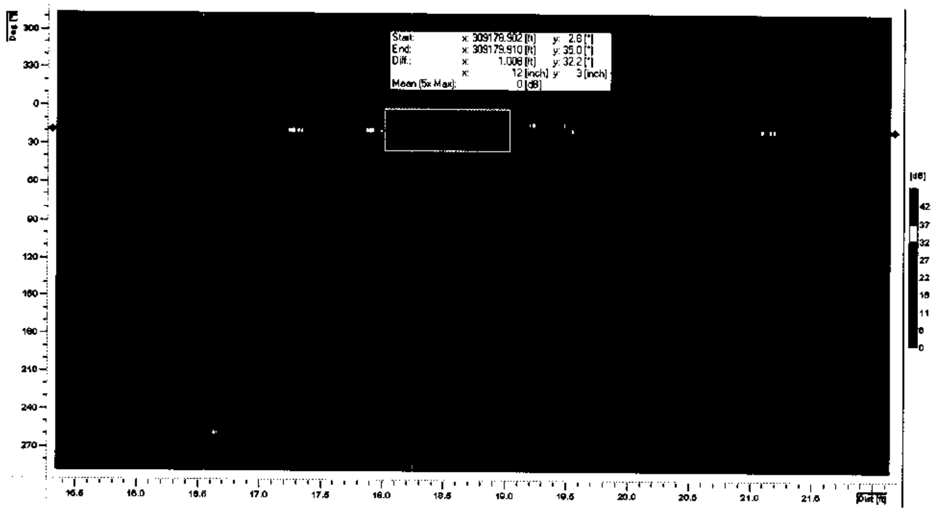
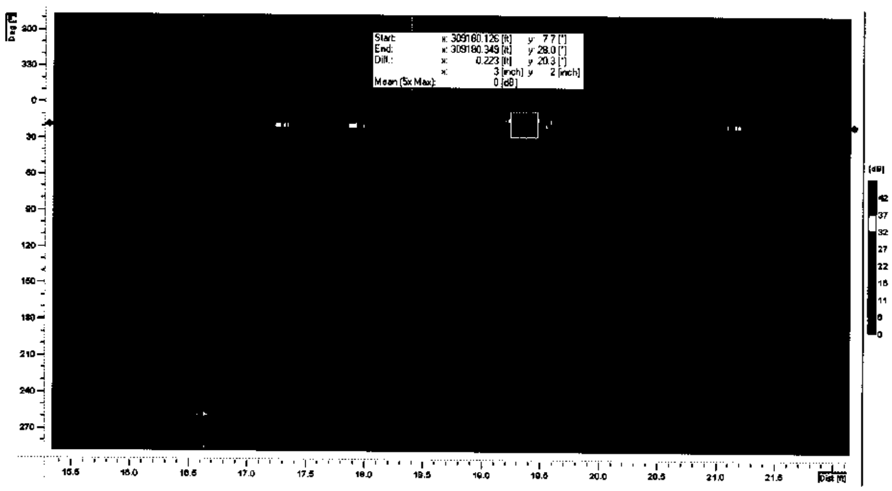


Distance between reflector Identified as numbers
(14 & 15) and (16 & 17) is 12 inches



Distance between reflector Identified as numbers
(16 & 17) and 18 is 3 inches

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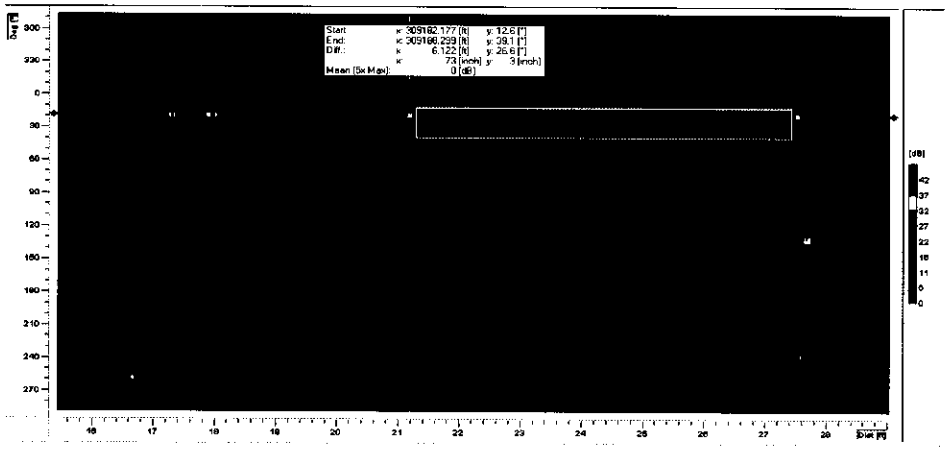
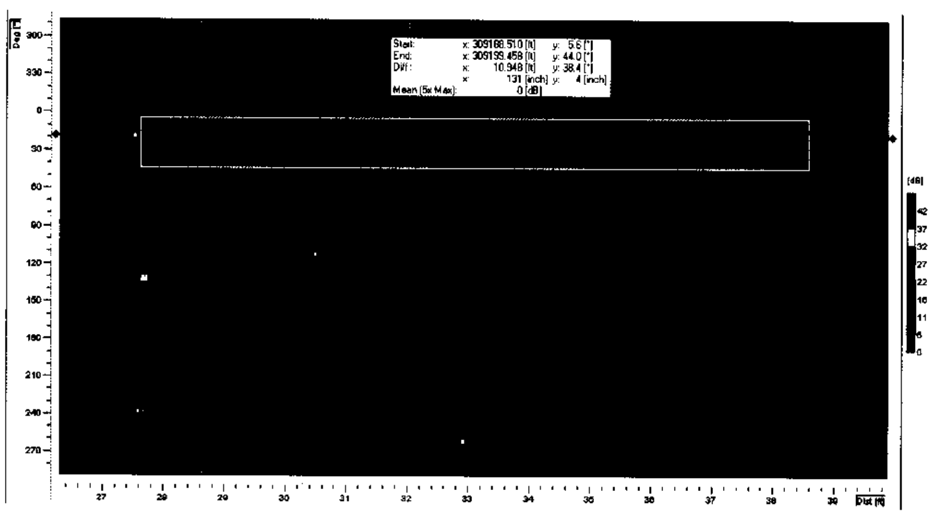


Distance between reflector Identified as numbers
18 and 22 is 73 inches



Distance between reflector Identified as numbers
22 and 26 is 131 inches.

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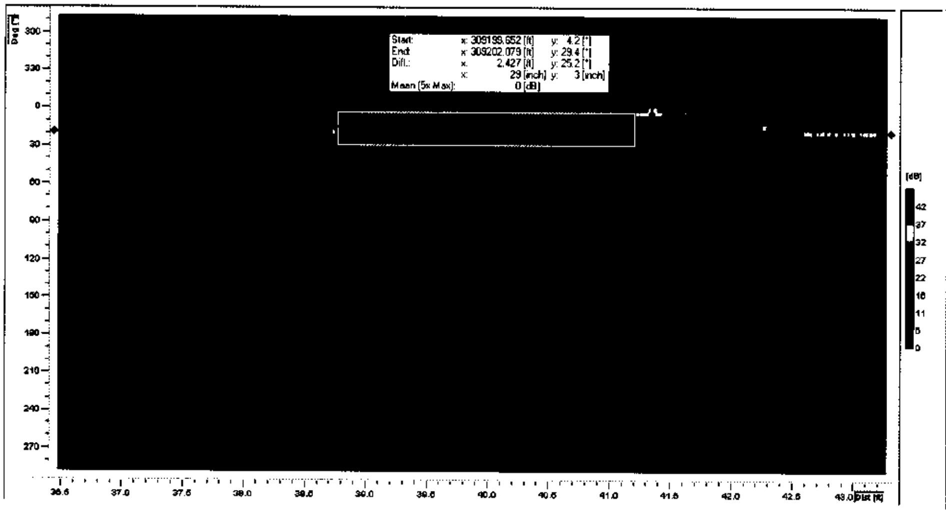
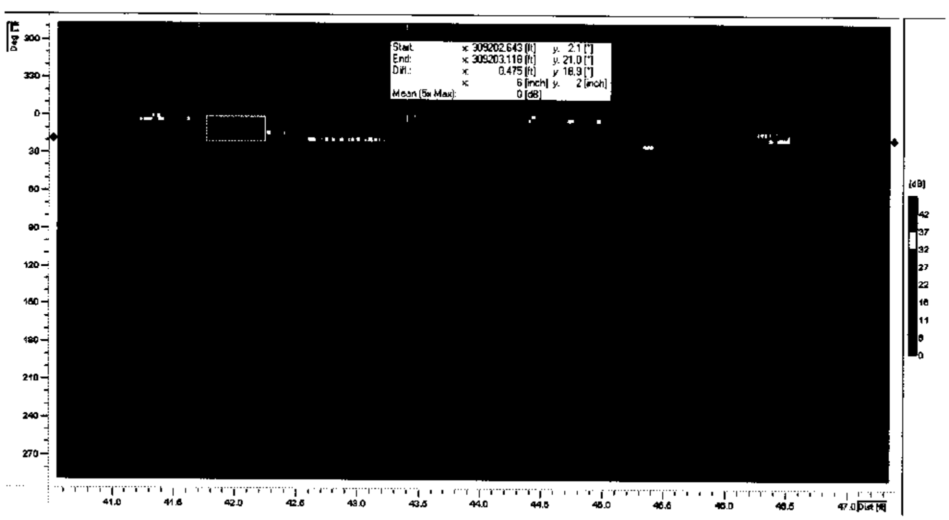


Distance between reflector Identified as numbers
26 and 27 is 29 inches



Distance between reflector Identified as numbers
27 and 28 is 6 inches

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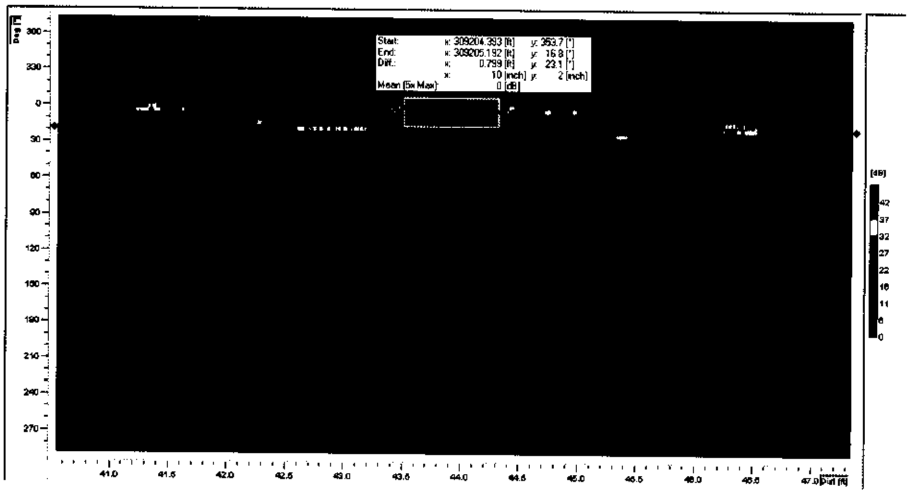
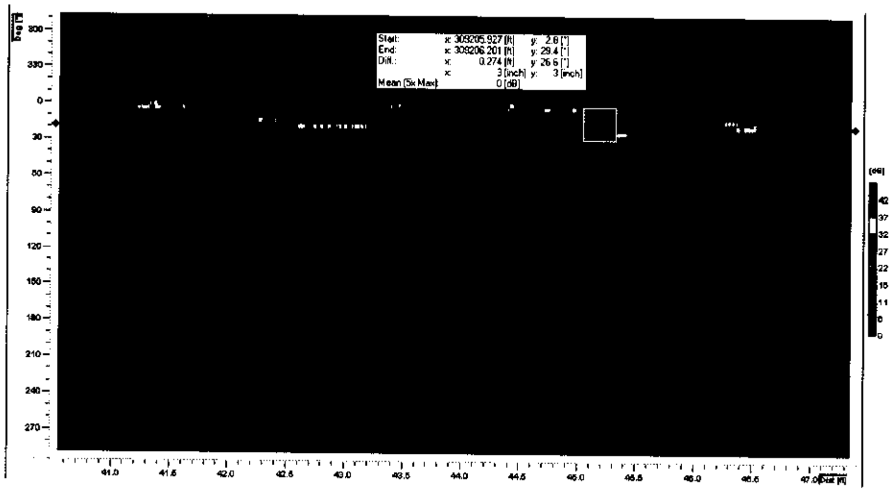
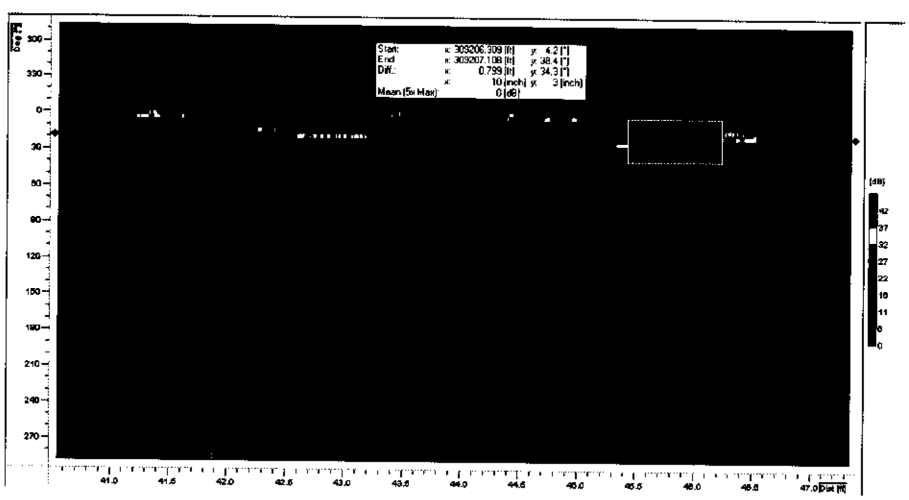


Distance between reflector Identified as numbers
29 and 30 is 10 inches



Distance between reflectors in location 31 is 3 inches



Distance between reflectors in location 31 is 10 inches

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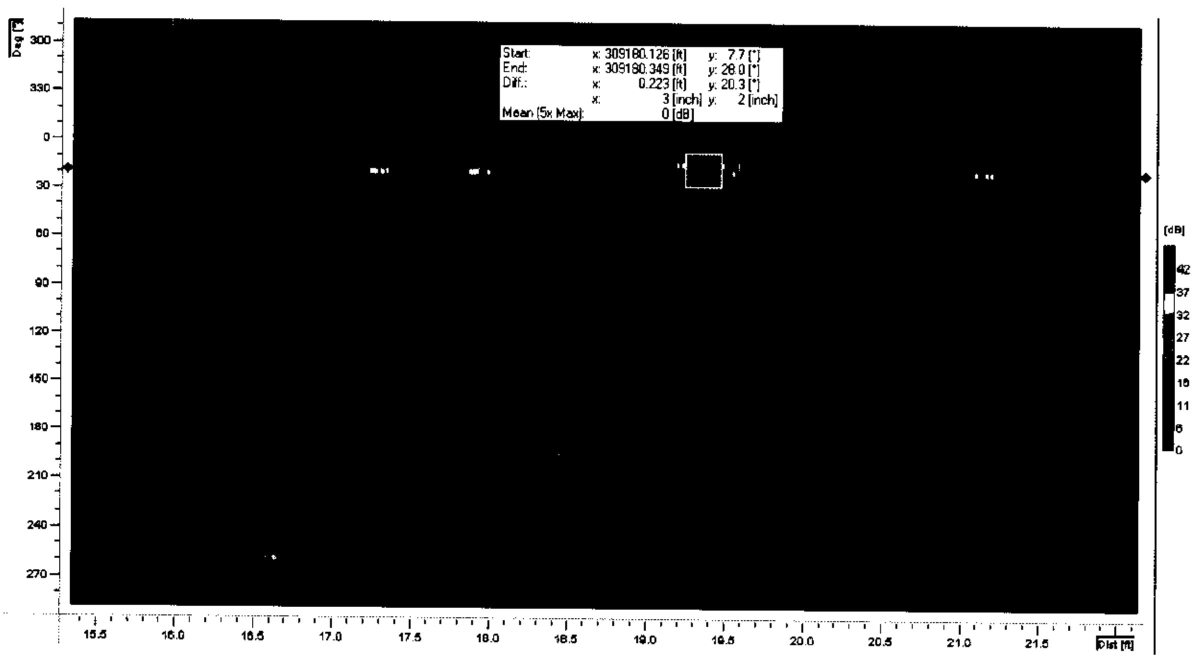

Distance between reflector Identified as numbers (16 & 17) and 18 is 3 inches

ID	D to GW [ft] U/S	Length [inches]	Depth (inches)
Feature 16	17.84	2	<0.040
Feature 17	19.05	2	<0.040
Feature 18	19.57	<1	0.040

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Ref Doc 10 - Engineering Critical Assessment of USCD Reported Defects – explanation of a Critical Crack

The "Critical crack size" referenced in our "Engineering Critical Assessment of USCD Reported Defects and Excavation Findings, Revision 6" definition is "The dimensions (length and depth) of any crack that would appear above or on the API 579 FAD level II curve and therefore requires further investigation.
The API 579 FAD level II graph was generated using the following criteria;-
The wall thickness provided by Dixie Pipeline as shown in section 13.5 pages 69-71 of a nominal 0.25".
An Operating Pressure of 1440 P.S.I.
The Material Fracture Toughness, determined by a specimen witch, was material tested. Out of 3 samples we took the lowest or most conservative value, as recommended in API 579, which is shown in table 1 page 25. We have a lowest value for the Seam weld, the HAZ (heat affected zone) and the base metal of the pipe.

The feature dimensions used in revision 6 were:-
USCD tool indicated length + 1% or 0.2" tolerance (whichever is largest) added.
USCD Tool Depth Upper Tolerance band.

There are 3 FAD levels of assessment, level I is a basic field assessment. level II is a practical Engineering assessment and Level III is a complex Ductile tearing instability assessment. If a crack should fail a level II assessment i.e. appear above or on the FAD II curve, a level III assessment or an infield investigation would be required. Due to the conservative nature of the FAD II assessment, cracks can appear on or above the curve without a pipeline failure having occurred. The explanation of this methodology is provided in the report on pages 6 & 7.
In reality the API 579 FAD II approach is to prioritize further investigations or field measurements to determine the appropriate mitigation method(s) required to reduce the risk of failure.

The "K at max load" is a Linear Elastic quantity, does not include the Plastic Deformation Energy part; but the "Plane Stress Kc" was converted from Jc, which was measured from the "area" under the test curve, based on "Elastic-plastic" strain energy, i.e. included the Plastic Deformation Energy part. Therefore, the Kc converted from Jc could be larger than the Kc measured from the max load.

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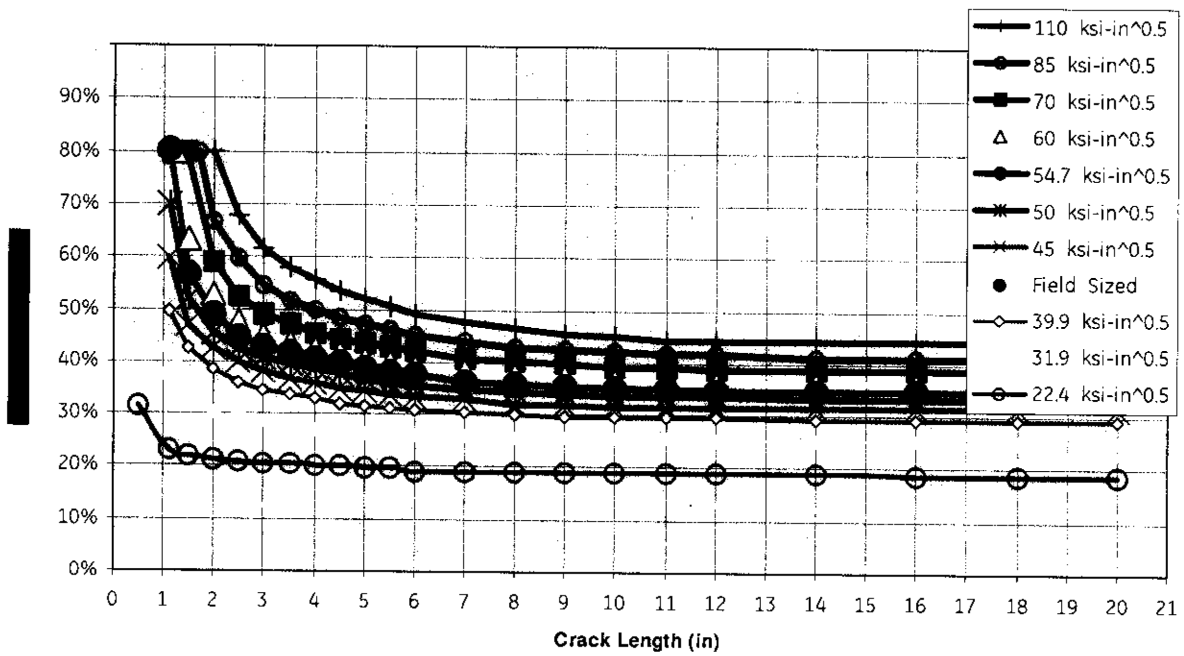
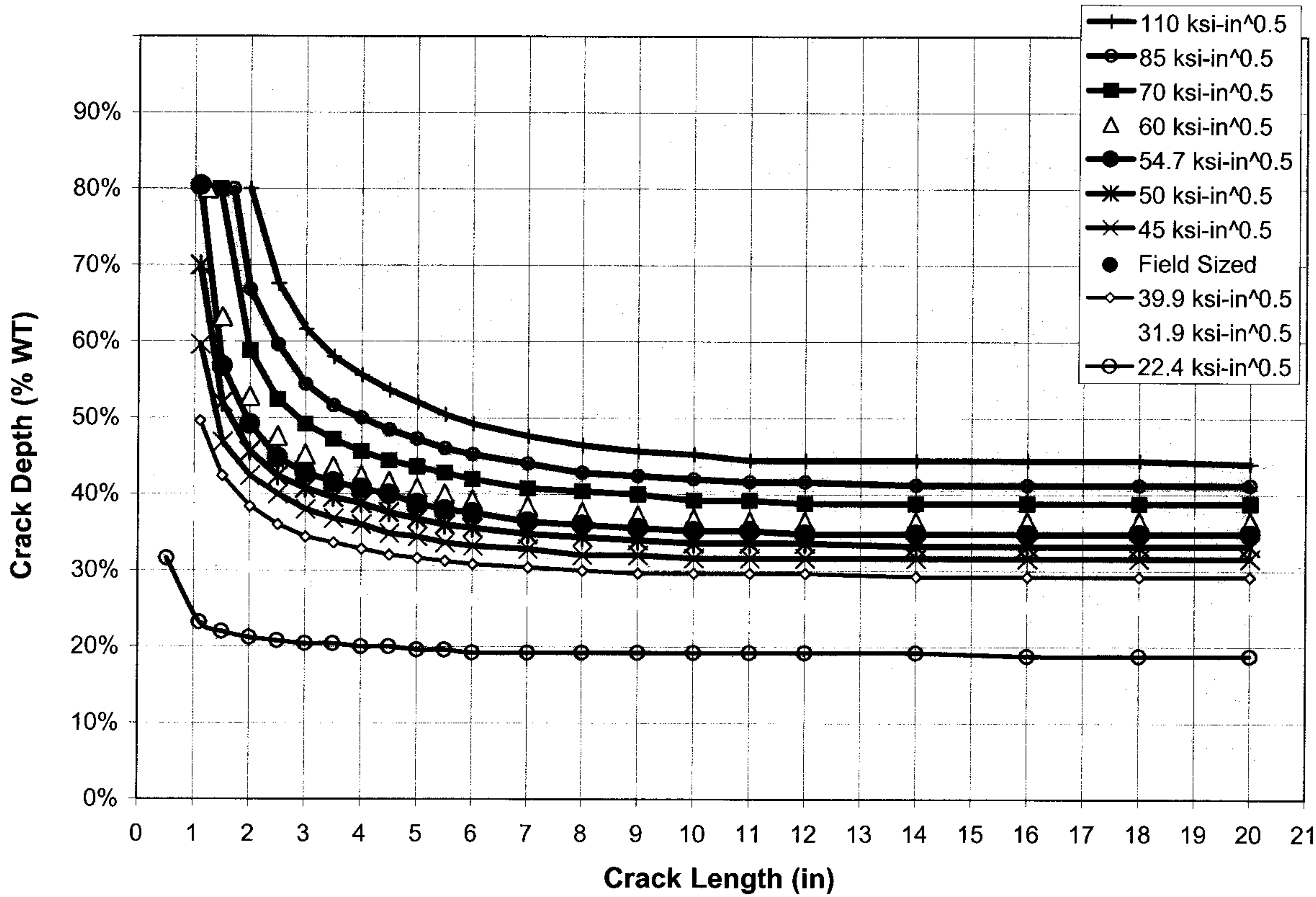
Ref Doc 11 – Fracture toughness curves @ 1441 psi




110 ksi-in^0.5
85 ksi-in^0.5
70 ksi-in^0.5
60 ksi-in^0.5
54.7 ksi-in^0.5
50 ksi-in^0.5
45 ksi-in^0.5
Field Sized
39.9 ksi-in^0.5
31.9 ksi-in^0.5
22.4 ksi-in^0.5
Crack Depth (% WT)
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
Crack Length (in)

P 34-B

Field Sized	length	8	in
	depth	**36%**	% WT

1440 psi

Ext surface crack

The depth is rounded to 3 digit decimals. The critical length is fixed, and the depth is set to 'just inside

In other words, depth + 0.001 inch will go outside of FAD line.

54.7 ksi-in^0.5			50 ksi-in^0.5			45 ksi-in^0.5			39.9 ksi-in^0.5			31.9 ksi-in^0.5		
Length (in)	Depth (in)	Depth (% WT)	Length (in)	Depth (in)	Depth (% WT)	Length (in)	Depth (in)	Depth (% WT)	Length (in)	Depth (in)	Depth (% WT)	Length (in)	Depth (in)	Depth (% WT)
												0.5	0.181	72.4%
1.1	0.201	80.4%	1.1	0.175	70.0%	1.1	0.149	59.6%	1.1	0.124	49.6%	1.1	0.093	37.2%
1.5	0.142	56.8%	1.5	0.130	52.0%	1.5	0.117	46.8%	1.5	0.106	42.4%	1.5	0.083	33.2%
2.0	0.123	49.2%	2.0	0.114	45.6%	2.0	0.106	42.4%	2.0	0.096	38.4%	2.0	0.076	30.4%
2.5	0.112	44.8%	2.5	0.106	42.4%	2.5	0.100	40.0%	2.5	0.090	36.0%	2.5	0.073	29.2%
3.0	0.107	42.8%	3.0	0.102	40.8%	3.0	0.095	38.0%	3.0	0.086	34.4%	3.0	0.071	28.4%
3.5	0.104	41.6%	3.5	0.099	39.6%	3.5	0.092	36.8%	3.5	0.084	33.6%	3.5	0.070	28.0%
4.0	0.102	40.8%	4.0	0.097	38.8%	4.0	0.090	36.0%	4.0	0.082	32.8%	4.0	0.068	27.2%
4.5	0.100	40.0%	4.5	0.094	37.6%	4.5	0.087	34.8%	4.5	0.080	32.0%	4.5	0.067	26.8%
5.0	0.097	38.8%	5.0	0.092	36.8%	5.0	0.086	34.4%	5.0	0.079	31.6%	5.0	0.066	26.4%
5.5	0.095	38.0%	5.5	0.090	36.0%	5.5	0.084	33.6%	5.5	0.078	31.2%	5.5	0.066	26.4%
6.0	0.094	37.6%	6.0	0.089	35.6%	6.0	0.083	33.2%	6.0	0.077	30.8%	6.0	0.065	26.0%
7.0	0.091	36.4%	7.0	0.087	34.8%	7.0	0.082	32.8%	7.0	0.076	30.4%	7.0	0.065	26.0%
8.0	0.090	36.0%	8.0	0.086	34.4%	8.0	0.080	32.0%	8.0	0.075	30.0%	8.0	0.064	25.6%
9.0	0.089	35.6%	9.0	0.085	34.0%	9.0	0.080	32.0%	9.0	0.074	29.6%	9.0	0.064	25.6%
10.0	0.088	35.2%	10.0	0.084	33.6%	10.0	0.079	31.6%	10.0	0.074	29.6%	10.0	0.064	25.6%
11.0	0.088	35.2%	11.0	0.084	33.6%	11.0	0.079	31.6%	11.0	0.074	29.6%	11.0	0.064	25.6%
12.0	0.087	34.8%	12.0	0.084	33.6%	12.0	0.079	31.6%	12.0	0.074	29.6%	12.0	0.063	25.2%
14.0	0.087	34.8%	14.0	0.083	33.2%	14.0	0.079	31.6%	14.0	0.073	29.2%	14.0	0.063	25.2%
16.0	0.087	34.8%	16.0	0.083	33.2%	16.0	0.079	31.6%	16.0	0.073	29.2%	16.0	0.063	25.2%
18.0	0.087	34.8%	18.0	0.083	33.2%	18.0	0.079	31.6%	18.0	0.073	29.2%	18.0	0.063	25.2%
20.0	0.087	34.8%	20.0	0.083	33.2%	20.0	0.079	31.6%	20.0	0.073	29.2%	20.0	0.063	25.2%

the FAD line.

22.4	ksi-in^0.5		60	ksi-in^0.5		70	ksi-in^0.5		85	ksi-in^0.5		110	ksi-in^0.5	
Length (in)	Depth (in)	Depth (% WT)	Length (in)	Depth (in)	Depth (% WT)	Length (in)	Depth (in)	Depth (% WT)	Length (in)	Depth (in)	Depth (% WT)	Length (in)	Depth (in)	Depth (% WT)
0.5	0.079	31.6%												
1.1	0.058	23.2%	1.23	0.200	80.0%									
1.5	0.055	22.0%	1.5	0.158	63.2%	1.46	0.200	80.0%	1.70	0.200	80.0%			
2.0	0.053	21.2%	2.0	0.132	52.8%	2.0	0.147	58.8%	2.0	0.167	66.8%	1.99	0.200	80.0%
2.5	0.052	20.8%	2.5	0.119	47.6%	2.5	0.131	52.4%	2.5	0.149	59.6%	2.5	0.169	67.6%
3.0	0.051	20.4%	3.0	0.113	45.2%	3.0	0.123	49.2%	3.0	0.136	54.4%	3.0	0.154	61.6%
3.5	0.051	20.4%	3.5	0.109	43.6%	3.5	0.118	47.2%	3.5	0.129	51.6%	3.5	0.145	58.0%
4.0	0.050	20.0%	4.0	0.106	42.4%	4.0	0.114	45.6%	4.0	0.125	50.0%	4.0	0.139	55.6%
4.5	0.050	20.0%	4.5	0.104	41.6%	4.5	0.111	44.4%	4.5	0.121	48.4%	4.5	0.134	53.6%
5.0	0.049	19.6%	5.0	0.102	40.8%	5.0	0.109	43.6%	5.0	0.118	47.2%	5.0	0.130	52.0%
5.5	0.049	19.6%	5.5	0.100	40.0%	5.5	0.107	42.8%	5.5	0.115	46.0%	5.5	0.126	50.4%
6.0	0.048	19.2%	6.0	0.098	39.2%	6.0	0.105	42.0%	6.0	0.113	45.2%	6.0	0.123	49.2%
7.0	0.048	19.2%	7.0	0.096	38.4%	7.0	0.102	40.8%	7.0	0.110	44.0%	7.0	0.119	47.6%
8.0	0.048	19.2%	8.0	0.094	37.6%	8.0	0.101	40.4%	8.0	0.107	42.8%	8.0	0.116	46.4%
9.0	0.048	19.2%	9.0	0.093	37.2%	9.0	0.100	40.0%	9.0	0.106	42.4%	9.0	0.114	45.6%
10.0	0.048	19.2%	10.0	0.092	36.8%	10.0	0.098	39.2%	10.0	0.105	42.0%	10.0	0.113	45.2%
11.0	0.048	19.2%	11.0	0.091	36.4%	11.0	0.098	39.2%	11.0	0.104	41.6%	11.0	0.111	44.4%
12.0	0.048	19.2%	12.0	0.091	36.4%	12.0	0.097	38.8%	12.0	0.104	41.6%	12.0	0.111	44.4%
14.0	0.048	19.2%	14.0	0.091	36.4%	14.0	0.097	38.8%	14.0	0.103	41.2%	14.0	0.111	44.4%
16.0	0.047	18.8%	16.0	0.091	36.4%	16.0	0.097	38.8%	16.0	0.103	41.2%	16.0	0.111	44.4%
18.0	0.047	18.8%	18.0	0.091	36.4%	18.0	0.097	38.8%	18.0	0.103	41.2%	18.0	0.111	44.4%
20.0	0.047	18.8%	20.0	0.091	36.4%	20.0	0.097	38.8%	20.0	0.103	41.2%	20.0	0.110	44.0%

Critical Cracks Sizes were Determined Based on:

1. FAD Level-II per API 579
2. External semi-elliptical surface crack
3. Axially oriented single crack with no coalescence modeled
4. Stationary cracks (cracks are not growing).
5. The calculated crack sizes do not represent the actual critical crack size that would fail at the prescribed pressure
6. The actual critical crack size or failure pressure is more accurately predicted by FAD Level-III Tearing Instability Approach
7. Nominal wall thickness of 0.250-inch
8. Nominal outside diameter of 12.75-inch

Yield Strength (SMYS)	52	ksi
Tensile Strength (minimum per API 5L)	66	ksi
Young's Modulus (E)	30,000	ksi
Fracture Toughness at the Seam Weld (K_{JMAT})	multiple values	ksi√in
Fracture Toughness in Base Material (K_{JMAT})	111	ksi√in

K (ksi-in^0.5) = 9.35x(CVN)^0.63
K (ksi-in^0.5), CVN (ft-lb)

K, ksi-in^0.5	CVN, ft-lb	
22.4	4	22.4
31.9	7	31.9
39.9	10	39.9
45	12.1	45.0
50	14.3	50.0
54.7	16.5	54.7
60	19.1	60.0
70	24.4	70.0
85	33.2	85.0
110	50.0	110.0

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Further Developments of the UltraScan CD Data Analysis Procedures since 2005

Changes since 2005

Crack Ranking
In an attempt to provide more useful information to operators with regard to their crack management programs, we have initiated a new product/report that provides the profile of a crack rather than just the max depth and length. This is most useful for long running cracks that would be severely overestimated iusing the original or conventional max length and overall depth dimensions.

SCC management
We also give an estimated severity ranking of SCC fields called "ESF" (Estimated Severity Factor) which provides a system for prioritizing mitigation of SCC fields.

Lessons Learned

For the PII Pipeline Solutions' Data Analysis Department it is crucial to always react properly on client's feedback from infield dig verification. The goal is to improve the data analysis capabilities and to keep a reliable quality standard for the whole inspection performance of inline inspection tools.

Recent improvement activities are related to the following items:

- Introduction of a training program
  to ensure a comprehensive knowledge about data analysis.
- Introduction of a quality check system and supporting software
  to ensure that an experienced analyst reviews all severe features.
- Introduction of a 'Production Consistency Test'
  to ensure the consistency of the analysed and checked data.
  Each quality checker has to analyse a certain number of different features before he starts with the quality check.
- Introduction of a 'Consistency Audit'.
  The leading analyst reviews a certain number of quality checked features of all experienced analysts during the quality check process.

Evolution of Training and Quality Check since 2005

Training

In 2003, a training program was introduced for the data analysis of ultrasonic data. Ongoing is a continuous improvement process based upon dig validation and lessons learned from other inspection experiences which are incorporated into this training program and contains 4 levels the analyst can achieve. This training program accompanies the analysts over 1.5 to 2 years to give the best possible education in data analysis.

Level 1 Trainee

After a training of 6 weeks the trainee has the knowledge of the ultrasonic technologies and the tool setup. He knows the data analysis process and he is has the capability to do data analysis i.e. he knows how to use the analysis software, identification of installations and feature classification using a selection of inspection data sets. The training ends with passing the knowledge test.

Level 1 Analyst

After 6 months of supervised data analysis, the analyst has to pass the Level 1 test.

Level 2 Analyst

After 1.5 years working as analyst, the level 2 training can be taken. In this training, the analyst learns how to generate a Pipebook, how to import marker data. The analyst also gets a basic knowledge about the data preparation. Additionally, experienced analysts are trained in doing the quality check and in report generation.

Level 3 Analyst, Team Leader

In the level 3 training, an experienced analyst with leading skills can achieve the Team Leader level. A training about how to audit a final report, how to give a report presentation, how to deal with clients etc is given.

1.1.1 Quality Check

In 1999, a quality check of all features meeting the reporting criteria was carried out. Additionally, spot checks on non-reportable features, i.e. irrelevant, geometry or weak inclusions, were established.

	Feature meeting the reporting criteria	Irrelevant feature	Weld IHG	Grinding at GW	Inclusion, weak notch
Level 1 trainee	100%	Spot checks	Spot checks	Spot checks	Spot checks
Level 1 analyst	100%	Spot checks	Spot checks	Spot checks	Spot checks
Level 2 analyst	100%	Spot checks	Spot checks	Spot checks	Spot checks

In 2005, a quality check based on the certification of the analyst was introduced (see following table). Depending on the experience of an analyst, the number of features to be checked increases or decreases.

	Feature meeting the reporting criteria	Irrelevant feature	Weld IHG	Grinding at GW	Inclusion, weak notch
Level 1 trainee	100%	10%	50%	50%	10%
Level 1 analyst	100%	5%	25%	25%	5%
Level 2 analyst	100%	0%	0%	0%	0%

In 2006, the quality check on geometries was increased. The analysis software was extended by the 'Quality Check Mode' to ensure the percentage of check given in the table below.

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	Feature meeting the reporting criteria	Irrelevant feature	Weld IHG	Grinding at GW	Inclusion, weak notch
Level 1 trainee	100%	20%	100%	50%	10%
Level 1 analyst	100%	5%	50%	26%	5%
Level 2 analyst	100%	0%	5%	3%	0%

Ref Doc 13 – New Products in Crack management from USCD tool reports since 2005

Crack Ranking

A new standard for ILI crack inspection

Our UltraScan™ CD in-line inspection (ILI) technology has logged more than 14 years of successful SCC and seam-weld crack inspections. During that time, pipeline operators have saved tens of millions of dollars by avoiding unnecessary line replacements and costly hydrostatic tests that provide only limited information on the future integrity of the pipeline.

Due to the unique morphology of cracks in steel pipelines, significant post-inspection work is often required in order to prioritize critical flaws by level of severity. This work may involve substantial excavations and NDE evaluations in order to decrease the conservatism built into ILI crack sizing. This process helps to ensure that the most severe cracks are given first priority.

In order to help operators with this important and costly challenge, GE Oil & Gas - PII Pipeline Solutions now includes our Crack Ranking service as part of our standard offering for all new crack inspections.

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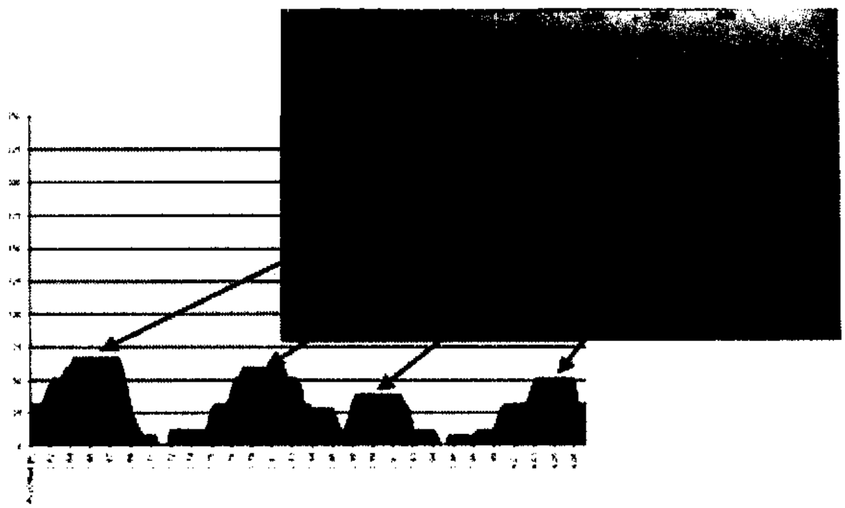
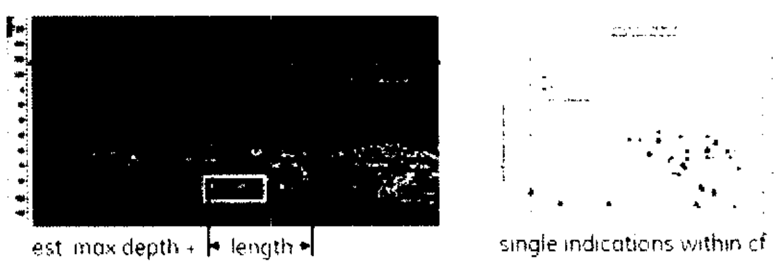
What is Crack Ranking?

PII's process provides operators with better resolution of individual defects, much like RSTRENG (LAPA) does for quantifying corrosion wall loss based on our MFL and ultrasonic measurement surveys. Our ILI crack inspection tools have historically identified crack length and the deepest point in an individual crack. By using depth profiling, we are able to assess the severity of a crack using a higher resolution crack profile, as shown in Figure A.



For SCC fields, individual cracks within the field are identified and isolated. An 'equivalent crack' is then derived using CEPA inter-linking rules to represent the field, as shown in Figure B. Once the depth profile for individual cracks and the 'equivalent crack' for SCC is complete, the crack severity is assessed using Linear Elastic Fracture Mechanics (LEFM).



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PII's integrity engineers prefer the API 579 assessment methodology for reasons defined in the PICA article.

Once the cracks are assessed using Linear Elastic Fracture Mechanics, the crack is then ranked relative to the other cracks on the pipeline segment and is given an Estimated Severity Factor (ESF). The cracks and corresponding ESF rankings are then provided to the operator in the final report. The end result is a crack severity prioritization list that provides the operator with a huge head start in establishing a sound dig validation and repair program.

Finally, this new enhancement offers significant value to any crack assessment (see PICA article) performed on the pipeline inspection data. The accuracy and optimization of any crack assessment exercise is heavily dependent on the accuracy of the inspection data and subsequent NDE validation data. The new Crack Ranking service included in our crack inspection is another tool to ensure the most accurate data for your crack assessment algorithms.

[redacted]
ILI Global Sales Leader